ATTACHMENT A

81437

Technical Review of Section 3 : Public Health and Environmental Risk Assessment, Appendix A-5: Groundwater, and Appendix A-7: Groundwater-Surface Water Interaction

in: Final Draft Groundwater and Surface Water Operable Unit Feasibility Study Galena Subsite Cherokee County Site, KS

February 26, 1988
WA Number 102-7L37.0
US Environmental Protection Agency

22 April 1988

Prepared By:

David E. Burmaster, Ph.D.
Charles A. Menzie, Ph.D.
Charles A. Menzie & Associates
Chelmsford, MA 01824
(617) 453-4300

I. GENERAL COMMENTS

Charles Menzie & Associates have carried out a technical review of three sections in the Final Draft of the Groundwater and Surface Water Operable Unit Feasibility Study (OUFS) for the Galena Subsite (US EPA, 1988b). This review focused on the interpretation of data, the use of data, and the assumptions made with regard to the performance of a risk assessment for the site. We have compared the risk assessment methods used in the Final Draft report with standard and state-of-the-art approaches that are being used throughout the country. Overall, we find that the approach used in the draft report is weak in a number of respects. The method used is similar to some that had been in use several year ago (i.e., similar assumptions, use of unrealistic worst case scenarios). The methods for conducting risk assessments have been advanced since these earliest risk assessments were performed. Information has been developed concerning assumptions related to exposures. General guidance has been established on how to represent realistic exposure scenarios. Unfortunately, few of these methods have been utilized in the draft report and it suffers from many of the same problems identified several years ago. As a result, the risk estimates provided in the document are not meaningful, i.e., because they are so unrealistic, they really don't provide information that can be useful from a risk management standpoint. In order for a risk assessment to serve a useful purpose it should convey useful information. This is a point we underscore in our course at Boston University and is one that most risk assessors would concur with.

A. Consideration of Background Concentrations

The study area near Galena, KS, has high concentrations of several metals, including lead and zinc, in the minerals forming the soils and rocks. In the past, people mined these ores commercially. However, the OUFS for the study area does not consider these natural conditions fully and properly. As detailed below in the specific comments:

- the public health risk assessment in Section 3 does not analyze the contribution and the effects of these natural concentrations in ground and surface waters and in soils,

- the environmental risk assessment in Section 3 discusses, but does not quantify, the contribution and the effects of these natural concentrations in surface waters,

- the ground water analysis in Appendix A-5 erroneously quantifies the contribution of these natural concentrations in ground water, and

- the ground and surface water model developed in Appendix A-7 compounds and propagates some of the errors created in Appendix A-5.

Overall, the original technical report does not properly and consistently distinguish between human health and environmental stresses from:

- concentrations of metals in ground and surface waters and in soils from (i) natural concentrations, (ii) the former mines, and (iii) the former smelter, and

- concentrations of other pollutants from other sources, such as those from municipal sewage treatment plants, from municipal nonpoint source runoff, from agricultural nonpoint runoff, and from upstream and upgradient contributions. Without making and quantifying the effects of these important distinctions, the report, sometimes explicitly and sometimes implicitly, implies that all the environmental problems and stresses in the study area have a single and consistent source -- the abandoned mines. While the mines may be a source of some of the current adverse conditions, the report makes little or no attempt to quantify and then partition or assign the responsibility among the possible sources.

B. Consideration of Zones and Subareas

The Galena Subsite area is far from homogeneous. Of the 18 square miles of land in the Galena Subsite, some 900 acres of it - or approximately 8 percent - is disturbed or covered with mining wastes. Of the many miles of stream in the subsite, Short Creek is the most highly stressed, while Empire Lake has few if any water quality exceedences even partially attributable to former mining activities in the area.

Notwithstanding the inhomogeneous conditions in the Galena Subsite, the OUFS for the study area does not consider these natural conditions fully and properly. As detailed below in the specific comments:

- the public health risk assessment broadly does not consider the differential conditions in the study area, and it frequently focuses on the worst conditions by using only maximum concentrations in several calculations, and,

- the ground water analysis in Appendix A-5 uses an incorrect statistical technique instead of the more conventional plume mapping to disaggregate the entire area.

Overall, the report, especially the public health risk assessment, leaves the reader with the mistaken impression that the entire Galena Subsite area has unacceptable environmental conditions. A richer and more robust analysis would have subdivided the OUFS study area into many subdivisions for separate and careful analysis.

C. Consideration of Information from the US Geological Survey

While the scope and timing of our technical review of the cited document did not permit a careful review of all research documents ever written about the study area, we did briefly review three recent reports prepared by the US Geological Survey. Broadly, the three documents do not convey the same impression to the reader as does the report under technical review. While we cannot fully evaluate the merits of the apparent discrepancies between the report under review and the three USGS reports, here are some impressions from the three USGS reports:

Excerpts from Barker (1977):

"In 1976, the US Geological Survey made a study of the effects of the abandoned and flooded mines and tailings piles on water quality .... " (p 2)

"Degradation of water quality is associated with the removal of (zinc and lead sulfides) from their reducing environment. Oxidation of insoluble metallic-sulfide minerals in the mines and tailings to a soluble form and subsequent solution and hydrolysis of the soluble sulfates produces sulfuric acid and liberates minerals. However, neutralization of the acid by calcium carbonate in the rocks ultimately results in high concentrations of calcium, sulfate, zinc in solution. Because of their insolubility, most other metals are rapidly precipitated." (p 4)

"Water in the (21) shallow wells is generally a calcium bicarbonate type ... Only four of the wells ..... have water with sulfate concentrations greater than 60 mg/l. Three of these are in, or very near mines, and the other is probably in contact with sulfide minerals..... Water from the other shallow wells is considerably less mineralized that the mine water." (p 12)

Excerpts from Marcher et al (1984):

"In addition to causing degradation of some stream waters, mineralized mine water might move into and contaminate water in shallow aquifers adjacent to the old mine workings; however, such movement does not appear to be widespread. Of greater significance, is the possible movement of mineralized water into the deep aquifers which are the principal source of supply for municipal and industrial use in the Tri-State district....." (p 18)

Excerpts from Spruill (1987):

"No conclusive evidence of evidence of lateral migration of water from the mines into domestic well-water supplies in the shallow aquifer was found in the study area in Kansas....." (p 1)

"In the absence of detailed sampling and site-specific drill-hole placement, it is difficult to evaluate the extent of lateral movement from the mines. However, water from shallow wells sampled for this study in the eastern area, located adjacent to and downgradient from the mines and generally in the limestone areas, did not exceed the maximum concentrations set for zinc and cadmium (table 7). Largest observed concentrations of these constituents may be the result of localized dissolution of sulfide deposits near the well. These results are consistent with the findings of Barks (1977) who reported that contaminated water was apparently confined to the mines..... (p 33)

D. Use and Misuse of Statistics

Generally, the OUFS report uses statistical and graphical techniques poorly or incorrectly. As computers have become more powerful, statisticians have increasingly used advanced graphics programs for exploratory data analysis (Chambers et al, 1983; Cleveland, 1985). With the ability to manipulate and view multivariate data, statisticians have documented many ways in which the use of simple summary statistics (such as the arithmetic mean, the arithmetic standard deviation, the median, the geometric mean, and/or the maximum) can mislead analysts from understanding the phenomena under study. With these new techniques, statisticians have also realized many weaknesses in the traditional methods of parametric tests, nonparametric tests, and multivariate linear regression (Chambers et al, 1983; Cleveland, 1985).

In these modern times, the OUFS report uses none of these modern statistical techniques. Only Appendix A-5 considers even the most elementary properties of distributions. The human health risk assessment too often uses only the maximum concentration for a metal in the analyses when even counts, averages, and medians would have been more informative and when new graphical techniques may have revealed unexpected relationships.

Finally, the Groundwater and Surface Water OUFS report does not consider the implications of the fact that many environmental variables have statistical distributions with long right tails, e.g., the lognormal distribution (Gilbert, 1987). Without a fundamental appreciation of the underlying statistical nature of the likely conditions in the Galena Subsite, the report's authors did not invoke techniques with sufficient power to make the proper distinctions.

II. SPECIFIC COMMENTS

Following the quotations or paraphrased material from the referenced pages, we make these comments:

A. Section 3: Public Health and Environmental Risk Assessment

PUBLIC HEALTH ASSESSMENT

p 3-3 "In all cases the maximum contaminant concentrations observed in a particular medium are used ... to represent a point of 'plausible maximum exposure'."

> Comment: While calculations based on maximum values are useful as a screening tool, it is not appropriate to call the results "plausible maximum exposures."

p 3-6 Table 3-2 summarizes the concentrations of total metals in 123 private wells by reporting the average and the maximum values.

> Comment: First, the table and accompanying text do not say if the 123 wells all tap the same aquifer at the same depth. Second, the maximum values for barium, cadmium, chromium, copper, lead, manganese, nickel, selenium, and zinc all exceed the average values by more than a factor of 4. This indicates that the values for any single metal are highly likely to come from underlying statistical distributions with long right tails, for example, a lognormal distribution (Gilbert, 1987). It is often misleading and inappropriate to summarize such variables with the arithmetic mean and maximum values, especially without making a histogram of the data to investigate their underlying distribution(s).

p 3-6 The body of Table 3-2 shows the MCL for chromium VI, not for chromium III.

> Comment: The report supplies no measurements which justify the use of the much lower MCL for chromium VI. Based on general thermodynamic arguments, one would expect find most of the chromium in the III state.

p 3-7 Table 3-3 also shows the MCL for chromium VI, not for chromium III.

Comment: Same as above.

p 3-8 "A 70-kg adult ingests 2 liters...." and "a 10-kg child ingests 1 liter..." of water per day.

Comment: While these are standard assumptions in public health risk assessments, the report does not state the assumption used to evaluate the ingestion of water by a 35-kg child, one of the human populations identified for analysis on p 3-4.

p 3-9 Table 3-5 shows only the maximum concentrations of dissolved metals in surface water.

Comment: The use of the maximum values, without any information about the underlying statistical distributions or even the arithmetic average, is inappropriate and likely misleading. Often, concentration measurements in natural waters follow a lognormal distribution for which the use of a maximum value as the summary statistic is highly misleading. The effects that are of primary interest in this risk assessment are chronic, i.e. resulting from long-term exposure. The appropriate statistic to use, therefore, is one that represents the level of exposure that would be expected on a long-term basis.

p 3-11 "Media intakes were based on a 35-kg child swimming in a surface water body for 1 hour each day."

Comment: First, the report has not established that children swim in any of the water bodies. Second, the report assumes implicitly that the 35-kg child swims every day of the year. These assumptions are not realistic and are inconsistent with assumptions EPA has made elsewhere for other superfund sites. Most risk assessments conservatively assume that children swim a day or two each week during the warm summer months. The overly conservative assumption in this report overstates the estimated exposure by a factor of 5 or more above the conservative assumptions normally used to gauge these possible exposures. Third, the US EPA's Superfund Exposure Assessment Manual (US EPA. 1986a) states that: "The local recreation department may have detailed data quantifying the duration and frequency of

water use for swimming. When such locale-specific data are not available, the following national averaged figures, based on data from the Bureau of Outdoor Recreation (cite) can be applied:

- o Frequency of exposure = 7 days / year
- o Duration of exposure = 2.6 hours / day"

p 3-11 "..it was assumed that the (35-kg) child had an exposed surface area pf 8,800 cm2 and was 75 percent submerged in the water."

Comment: It is implausible and misleading to assume that a 35-kg child remains 75-percent submerged while swimming for an hour a day.

p 3-11 "It was assumed that this flux (of water) was 0.5 mg/cm2/hr."

Comment: The report implicitly assumes that this estimated flux of water will carry metal ions through the skin, thereby causing a dose. This is inappropriate and misleading because ionized species do not cross the skin barrier, as per these three references:

1. "Generally, only lipid-soluble, non-ionized compounds are absorbed significantly through the skin." (p 6-6; US EPA, 1986b)

2. "Very little cadmium enters the body through the skin." (p 1) and "Cadmium compounds have not been observed to cause significant health effects when exposure in by the dermal route." (p 17; ATSDR, 1987).

3. "The general population comes in frequent skin contact with lead in the form of lead-containing dusts and soil; however, only small amounts of the element will enter the body after skin contact." (p 3; ATSDR 1988) and "Dermal: Pertinent dose-effect data were not found in the available literature." (p 16; ATSDR, 1988).

p 3-11 "The daily intakes for incidental ingestion and dermal absorption (during swimming) were multiplied by the maximum dissolved concentrations of each metal in the water to obtain a daily intake of each metal."

Comment: It is inappropriate and misleading to use the maximum concentrations in these calculations, for two reasons. First, the use of the maximum is a grossly misleading summary statistic for variables having a long right tail, such as ones distributed in a lognormal distribution Second, the report has not demonstrated that any persons swim in the areas with the highest concentrations.

p 3-13 Paraphrased: Soil samples during the RI were taken downwind of the former Galena smelter, and soil samples during the FS were taken in 8 mine waste zones.

Comment: Neither the RI nor the FS has made any attempt to measure "representative" concentrations near Galena. The US EPA (i) used a "sampling dirty" sample plan designed to obtain the highest possible values, not representative values and then (ii) used these worst-worst case values in subsequent analyses. This is inappropriate, and the results may overstate otherwise "representative" or "average" analyses by as much as several orders of magnitude.

p 3-14 "A 10-kg child ingests 1 gram of contaminated soil or mine waste per day."

Comment: It is unlikely and inappropriate to model a 10-kg child (say, ages 1 through 3 years) as eating 1 gram of soil each and every day, especially dirt from the most contaminated waste piles and soils downwind of the former smelter. First, parents and caretakers of children in this age range rarely let them play in industrial waste sites. Second, rain, snow, ice, and frozen soils would limit the ingestion of soils on many days of the year, even if children happened play in the most contaminated areas. Third, recent review articles suggest that 1 gram per day for the ingestion of soils by children is a gross exaggeration. More specifically, LaGoy (1987), in a major and authoritative review, estimates that a 10-kg child ingests an average of 50 mg of soil per day and a maximum of 250 mg of soil per day from all sources, not just from heavily contaminated sites. Similarly, Paustenbach (1987) states, "When all this published information on soil ingestion is considered, the data indicate that a consensus estimate for soil ingestion by children (ages 1.5 to 3.5 years or ages 2 to 4) is about 100 mg / day. This figure

was used by the EPA in its risk assessment and in the EPA Superfund Health Assessment Manual." Thus, the value of 1 gram / day (1,000 mg/day) assumed in this report overstates other authoritative and conservative estimates by a factor of 10 or 20 on mass alone.

p 3-15 "A 70-kg adult ingest 0.1 grams of contaminated soil or mine waste per day."

Comment: It is unlikely and inappropriate to model the typical 70-kg adult (say, over age 18) as eating 0.1 gram (100 mg) of soil each and every day, especially dirt from the most contaminated waste piles and soils downwind of the former smelter. First, adults do not normally spend each day in industrial waste sites. Second, rain, snow, ice, and frozen soils would limit the ingestion of soils on many days of the year, even if adults happened visit the most contaminated areas every day. Third, recent review articles suggest that 0.1 gram per day for the ingestion of soils by adults is a gross exaggeration. More specifically, LaGoy (1987), in a major and authoritative review, estimates that a 70-kg adult ingests an average of 25 or 50 mg of soil per day and a maximum of 100 mg of soil per day from all sources, not just from heavily contaminated sites. Similarly, Paustenbach (1987) states, "Even having considered the contribution of poor hygiene and soil-contaminated food, the 100 mg / day figure used by CDC to estimate soil uptake by adolescents and adults seems unlikely, and a figure of 0 to 10 mg / day seems more reasonable and supportable." " Thus, the value of 0.1 gram/ day assumed in this report may overstate other authoritative and conservative estimates by a factor of 4 to 10 or more on mass alone.

p 3-16 Table 3-10 is based on maximum metal concentrations.

Comment: It is inappropriate and misleading to use the maximum metal concentrations for two reasons. First, the contractors "sampled dirty" and thereby biased the measurements. Second, soil concentrations usually follow an underlying statistical distribution called the lognormal distribution for which the the maximum value is a grossly misleading summary statistic. Because the effects that are of interest are those associated with chronic (long-term) exposures, the appropriate statistic to use is one that takes into account the central tendancy of the exposure point concentrations.

p 3-17, 18 "It was assumed for the purpose of this analysis that all fish eaten are from locally contaminated waters."

Comment: First, the report has not established that people catch and eat fish from the local waters, much less the most contaminated reaches. Second, the report has not established that any local fishery could support even one person who caught and ate 6.5 grams of fish each and every day for a 70-year lifetime.

p 3-18, 19 "For children, the exposure scenario consists of a 10-kg child consuming ..... 6.5 grams of fish per day."

Comment: It is inappropriate and misleading to assume that a 10-kg child (say, ages 1 through 3) eats as much fish everyday as an adult. If children eat fish in proportion to their body mass, they would ingest under 1 gram per day (Anderson et al, 1984). If children eat fish in proportion to their average daily energy expenditure (in kcal / day), the amount of fish would ingest 1 or 2 grams per day (Snyder et al, 1975). It is also appropriate to note that many children in this size and age range do not eat fish as frequently as do adults.

p 3-19 "For both children and adults, the primary pathways of exposure are ingestion of contaminated groundwater and ingestion of contaminated soil or waste."

Comment: It is important to note that swimming and eating contaminated fish are not primary pathways of exposure (even under the exaggerated assumptions on the magnitude, duration, and frequency of exposure) because the other pathways are in fact "larger" and because the analyses of the other pathways also suffer from exaggerated assumptions.

p 3-26 "At the present time, EPA considers drinking water and promulgated state water quality standards ..... to be potentially applicable or relevant and appropriate standards."

Comment: It is not clear that the Congress or the US EPA intends that the MCLs and MCLGs developed under the federal Safe Drinking Water Act are to be used as "ARARs" for ground water in mining districts, precisely because the concentrations of some or many metallic ions may exceed the MCLs or MCLGs at present and may have done so for eons.

p 3-27 "Cancer potencies were obtained from EPA's Superfund Public Health Assessment Manual."

Comment: The Agency has established the Integrated Risk Information System (IRIS Database) (US EPA, 1987) as the most authoritative source of cancer potency factors and the PHRED database for updates to the Superfund Public Health Evaluation Manual (US EPA, 1988a).

p 3-29 In Table 3-16, the report lists chromium VI.

Comment: The report has not established that any chromium VI is present in the study area. On general thermodynamic grounds, one would expect to find most of all of the metal as chromium III.

p 3-30 "A comparison of maximum contaminant concentrations observed in private wells to applicable criteria is presented in Table 2-5."

Comment: It is inappropriate to assess all the private drinking water wells on the maximum concentration for each compound, especially because the maximum concentrations may come from different wells. At a minimum, the report should include (i) a count of the number of wells measured (n=123) that exceed each individual criterion and (ii) a count of the number of wells that exceed more than one criterion simultaneously. As stated before, concentrations of metals dissolved in ground water commonly follow a lognormal statistical distribution. As a summary statistic, maximum concentrations grossly exaggerate any ion distributed according to a lognormal distribution.

p 3-33 "The common range of arsenic concentrations in soil is 1 to 50 ppm (Lindsay, 1979). Therefore, ingestion of soil containing natural background levels presents a risk comparable to that calculated for the soils and mine wastes at Galena."

Comment: First, this is the first mention in the risk assessment of natural background concentrations any metal in soil. In fact, all soils in all locations contain natural background concentrations, and every risk assessment must acknowledge their presence and focus on "elevated" concentrations that may be present from human activities. Second, as a legal and policy matter, it is not clear that the Congress and the US EPA wish to clean up any site to concentrations <u>below</u> those representing natural background concentrations in a locality.

p 3-34 ".... chromium (assumed to be chromium VI) ...."

Comment: The report has not presented any evidence on the presence of chromium VI anywhere in the study area.

p 3-35 ".... chromium (assumed to be chromium VI) ...."

Comment: Same as above.

p 3-36 "First, the accuracy or reliability of the source characterization must be reviewed."

Comment: All analysts support this principle. Unfortunately, the risk assessment falls unacceptably short of the ideal for two reasons. First, the risk assessment too often uses maximum concentrations instead of better summary statistics -- or, better still, the full distributions themselves -- to assess a complicated situation. Second, the risk assessment makes no attempt to distinguish between (i) natural background concentrations and (ii) concentrations elevated by human activities. People mined ores near Galena precisely because the minerals contain(ed) high natural concentrations of certain valuable metals. While the people living near Galena may experience higher health risks than other persons living in areas of the country without the ore deposits, it is essential to distinguish naturally occurring background concentrations and risks from ones elevated by human activities.

p 3-36 "Secondly (sic), the plausibility of the exposure scenarios must be considered. The existence of an exposure pathway may be firmly documented or it may only be postulated."

Comment: All analysts support this principle. Unfortunately, the present risk assessment does not follow it. As an example of a grossly exaggerated exposure scenario, the risk assessment assumes that children weighing 10 kg (say, ages 1 through 3) will eat 1 gram of soil from the most contaminated areas in the county every day, even in the winter. This scenario is not plausible; it fails the principle stated by the authors.

p 3-38 Table 3-24 suggests that each item may underestimate or overestimate health risks.

Comment: While this may be true, the authors of the risk assessment have chosen values and scenarios that are much more likely to have overestimated the risk than to have underestimated the risk. While all risk assessments

properly should use a conservative approach (i.e., one protective of public health), it is not proper or appropriate to choose a maximum value for every single parameter and variable in a calculation. By multiplying a series of extreme values, the authors create a scenario that is so unlikely as to be implausible and misleading.

p 3-41 "Furthermore, all potential exposure pathways have a common source -- the mine wastes."

Comment: First, even in the narrow logic of the risk assessment, this is a false statement. For example, all of the soil samples taken during the RI and used as a partial basis of this risk assessment were taken downwind of the former smelter. Second, in the broader context, the risk assessment makes no attempt to distinguish (i) concentrations and risks attributable to natural background in an area with economic ores from (ii) concentrations and risks attributable to elevations caused by human activities.

ENVIRONMENTAL RISK ASSESSMENT

p 3-42 " A 1982 sampling program on Short Creek (EPA, 1982) investigated the influence of discharges form a fertilizer plant in Missouri ..." and "The sources of pollutants included a 70-acre fertilizer plant as well as ...."

Comment: The rest of the environmental risk assessment does not distinguish among (i) these sources, (ii) mining sources, and (iii) natural conditions. Specifically, the report makes no mention of other point and nonpoint sources of loadings to any of the rivers, lakes, and impoundments in the study area. For example, the report does not consider the presence or absence of (i) municipal sewage treatment plants, (ii) municipal combined sewer overflows, (iii) industrial waste water discharges, (iv) agricultural runoff, or (v) other sources of (other) pollutants that can stress a biota in surface waters.

p 3-51 "KDHE stated .... that .... high nutrient loading and other water quality violations were confined largely to the Short Creek Watershed."

Comment: The environmental risk assessment does not analyze the sources or effects of these high nutrient loadings.

p 3-62 "The biota of Short Creek have been severely impaired by AMD. Discharges from the fertilizer plant ... and nonpoint groundwater inflow ..... add to the overall toxicity.... in Short Creek. Ammonia discharges, apparently from the fertilizer plant, exceed water quality criteria and compound problem with toxic metals. However, calcium discharges .... from the fertilizer plant increase hardness and .... reduce the toxicity effect of zinc, cadmium, and lead."

> Comment: Notwithstanding the fact that the paragraph contradicts itself, the environmental risk assessment makes no attempt to quantify the relative contributions and interactions of the materials from the several sources. Readers of the environmental risk assessment cannot determine the importance of the different sources of biological stress to the water ways.

B. Appendix A.5: Groundwater

p A-36 "Metals concentrations in groundwater can be used to separate the private wells into two groups -- one with minimal relationship with groundwater in the mine workings and another group which can be related directly to groundwater in the mine workings. The first group includes ground water that is described alternatively as having background, baseline, or threshold metals concentrations, and the second as affected, impacted, or anomalous metals concentration ranges."

> Comment: The conceptual distinction made here between background concentrations and anthropogenic elevations of concentrations does not appear in the public health risk assessment.

p A-36 "The ability to separate the water quality of private wells into threshold and anomalous concentration ranges .... leads to a probabilistic or statistical analysis rather than plume definition..... Frequency distributions of metals concentrations is a scientifically rigorous, objective statistical technique used .... to separate threshold (peripheral mineralization) from anomalous (potential ore deposit drilling targets) metal concentrations. The technique is a graphical statistical technique plotting metal concentration (ug/l) versus cumulative percent of samples..... A single group of metal concentrations ... will plot as a straight line on the cumulative frequency distribution graph. ....." (with continuing sentences).

> Comment: First, the authors offer no literature citations to support these assertions. Second, prima facie, the assertion that: "A single group of metal concentrations ... will plot as a straight line on the cumulative

frequency distribution graph. ....." is false. See, for example, Hastings and Peacock (1974). In general, with the exception of the uniform probability density function, all probability density functions (for single statistical populations) plot as a rising curve with an asymptote of 1 as the random variate tends to its upper bound. Third, in Figures A-12 through A-16 for total lead, total zinc, dissolved zinc, total cadmium, and sulfate, respectively, the authors place great emphasis on the power of two fitted, linear regression lines to distinguish between two statistical distributions which they hypothesize as underlying the field data. Unfortunately, the method is wrong and misleading.

While the proof that the report's technique is wrong in general presupposes a strong foundation in theoretical statistics, it is easy to demonstrate a counter example in which the report's technique creates a counterfactual conclusion. Based on the data and regressions lines shown in Figure A-12 from Appendix A.5 and reproduced as Exhibit 1 with this technical review, the authors of the original report conclude that the values below the breakpoint (at 7.9 ug/l of total lead) come from one statistical distribution and that the values above the breakpoint come from a second distribution. They also conclude that the two underlying distributions have means that are significantly different at the 99 percent confidence level (see p A-38 of the report). They further conclude that "there is only only one in 100 analyses that could be misclassified in the two groups" (p A-38).

Contrast the claims of the authors of the original report with the values and fitted lines in shown in Exhibit 2, as prepared for this technical review. Using the same logic as in Appendix A.5, one would conclude that the values come from two underlying statistical distributions that have different means at some high degree of confidence. However, the 20 values plotted in Exhibit 2 come from a single lognormal distribution!

Many environmental variables are distributed in lognormal distributions (Gilbert, 1987), a distribution typically having a long right tail. As such, lognormal distributions commonly have cumulative plots that rise strongly from the origin and then eventually asymptote at one as the random variate reaches it upperbound. A naive person might try to fit two straight lines to the cumulative plot in an effort to understand the data, but it would be wrong to conclude from the exercise that the values come from two underlying distributions. The values come from a single statistical population simulated by Monte Carlo technique (see, for example, Morgan, 1984, or Rubinstein, 1981) and any inference that the two fitted straight lines represent two underlying phenomena is flat wrong.

Exhibit 1
Frequency Distribution
Cited in Appendix A-5: Groundwater

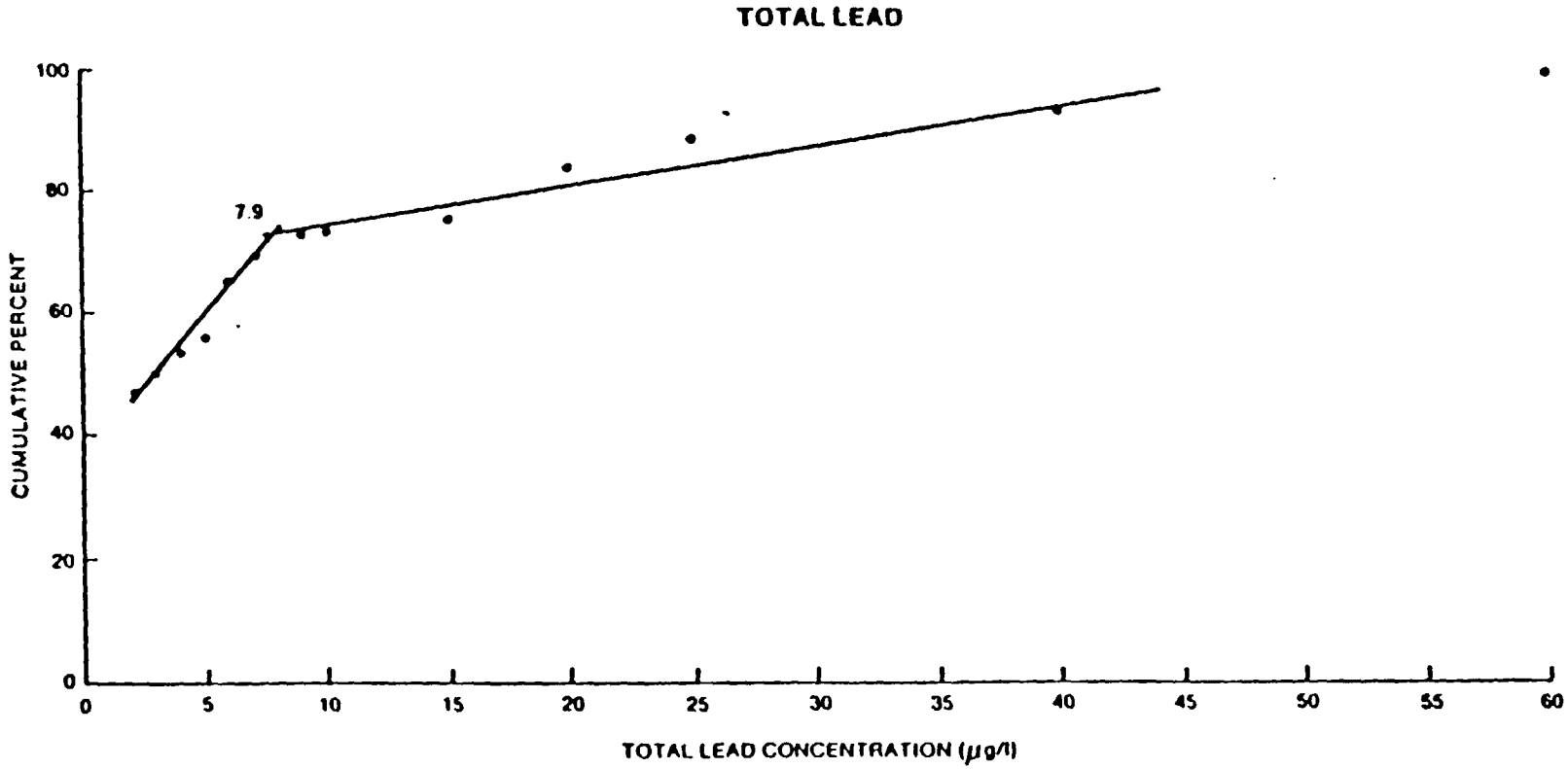
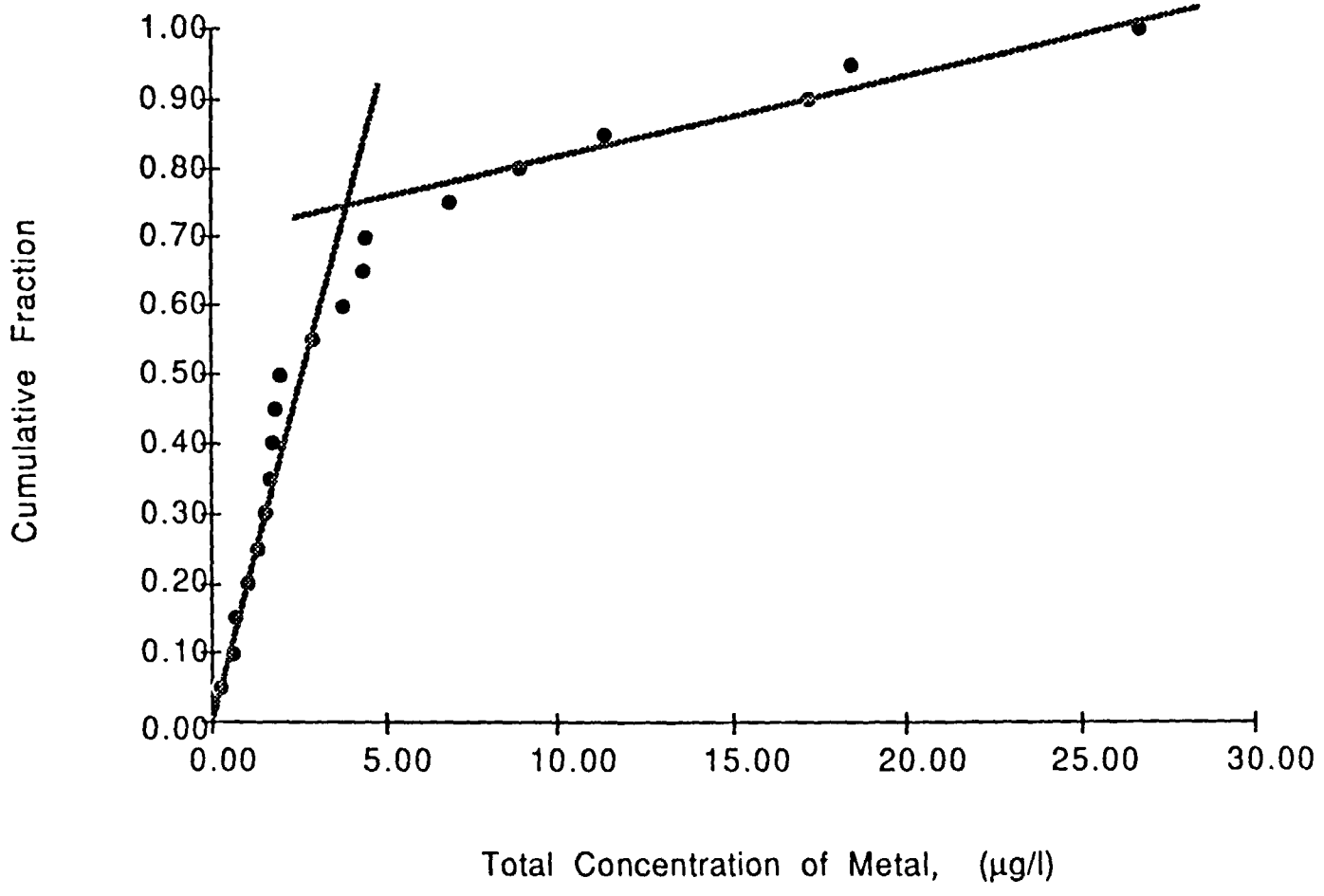


FIGURE A-12
FREQUENCY DISTRIBUTION FOR TOTAL LEAD IN GROUNDWATER FROM PRIVATE WELLS
CHEROKEE COUNTY, KANSAS
GALENA SUBSITE — OUFS
GROUNDWATER/SURFACE WATER

Exhibit 2
Cumulative Frequency Distribution for
Synthetic Data Simulated from a Single Lognormal Distribution



p A-45 "In summary, the statistical evaluation of the shallow groundwater private well water quality defines two significantly different groups. One group, the threshold group with low concentrations, is probably related to random natural mineralization in the subsite. The other group, the anomalous group with higher concentrations, is statistically related to the mine workings...."

> Comment: First, note the use of "probably" in the second sentence. The authors of the original report understand that they do not have a causal model. Second, and more importantly, the method is wrong in that it can create distinctions where none are present.

C. Appendix A.7: Groundwater-Surface Water Interaction

p A-90, 91 "To evaluate the changes to water quality occurring in the Galena watersheds, it is necessary to establish water quality in areas tributary to the subsite but unaffected by the surrounding mine wastes and subsurface geochemical reactions occurring in the subsite." and "Groundwater Quality. The analysis to support the groundwater concentrations have been previously discussed in Section A-5."

> Comment: To the extent that the model developed in this section relies on the faulty analysis in Appendix A-5, the conclusions in this section are also faulty.

References

Anderson et al, 1984

Anderson, E. et al, 1984, Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments, Revised Draft Final Report, prepared by GCA Technology Division, GCA Corporation, Chapel Hill, NC, for the Exposure Assessment Group, Office of Health and Environmental Assessment, US Environmental Protection Agency, Washington, DC

ATSDR, 1987

US Agency for Toxic Substances and Disease Registry, US Public Health Service, Toxicological Profile for Cadmium, Draft for Public Comment, Atlanta, GA, November 1987

ATSDR, 1988

US Agency for Toxic Substances and Disease Registry, US Public Health Service, Toxicological Profile for Lead, Draft for Public Comment, Atlanta, GA, February 1988

Chambers et al, 1983

Chambers, J.M. et al, 1983, Graphical Methods for Data Analysis, Wadsworth International Group, Belmont, CA

Cleveland, 1985

Cleveland, W.S., 1985, The Elements of Graphing Data, Wadsworth Advanced Books and Software, Monterey, CA

Barks, 1977

Barks, J.H., 1977, Effects of Abandoned Lead and Zinc Mines and Tailings Piles on Water Quality in the Joplin Area, Missouri, Water-Resources Investigations 77-75, US Geological Survey, US Geological Survey, Rolla, MO, August 1977

Gilbert, 1987

Gilbert, R.O., 1987, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold Company, New York Hastings & Peacock, 1974 Hastings, N.A.J. and J.B. Peacock, 1974, Statistical Distributions, a Handbook for Students and Practitioners, Butterworth & Company, London

LaGoy, 1987

LaGoy, P.K., 1987, Estimated Soil Ingestion Rates for Use In Risk Assessment, Risk Analysis, Vol 7, No 3, pp 355 - 359

Marcher et al, 1984

Marcher, M.V., J.F. Kenny, and others, 1984, Hydrology of Area 40, Western Region, Interior Coal Province, Kansas, Oklahoma, and Missouri, Water- Resources Investigations Open File Report 83-266, US Geological Survey, Oklahoma City, OK and Lawrence, KS, April 1984

Morgan, 1984

Morgan, B.J.T., 1984, Elements of Simulation, Chapman and Hall, London

Paustenbach, 1987

Paustenbach, D.J., 1987, Assessing the Potential Environment and Human Health Risks, of Contaminated Soil, Comments on Toxicology, Vol 1, No 3 - 4, pp 185 - 215, May 1985

Rubinstein, 1981

Rubinstein, R.Y., 1981, Simulation and the Monte Carlo Method, John Wiley & Sons, New York, NY

Snyder et al, 1975

Snyder, W.S. et al, 1975, Report of the Task Group on Reference Man, Report Number 23, International Commission on Radiological Protection, Pergamon Press, Oxford

Spruill, 1987

Spruill, T.B., 1987, Assessment of Water Resources in Lead-Zinc Mined Areas in Cherokee County, Kansas, and Adjacent Areas, Water-Supply Paper 2268, US Geological Survey, US Government Printing Office, Washington, DC

US EPA, 1986a

US Environmental Protection Agency, 1986, Superfund Public Health Evaluation Manual, EPA/540/1-86/060, OSWER Directive 9285.4-1, Washington, DC, October 1986

US EPA, 1986b

US Environmental Protection Agency, 1986, Superfund Exposure Assessment Manual, Revised Draft, OSWER Directive 9285.5-1, Washington, DC, December 1986

US EPA, 1987

US Environmental Protection Agency, Integrated Risk Information System (IRIS), Volume I, Supportive Documentation, Washington, DC, March 1987

US EPA, 1988a

US Environmental Protection Agency, Public Health Evaluation Database (PHRED), Users Manual, Office of Solid Waste and Emergency Response, Washington, DC, 19 February 1988

US EPA, 1988b

US Environmental Protection Agency, 1988, Groundwater and Surface Water Operable Unit Feasibility Study, Final Draft, Galena Subsite, Cherokee County Site, KS, Volumes 1 through 3 with Appendices of the OUFS Report, prepared under contact by CH2MHill, Black & Veatch, ICF, PRC, and Ecology and Environment, February 26, 1988.